EM12-G Hardware Design

LTE-A Module Series

Rev. EM12_Hardware_Design_

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Our aim is to provide customers with timely and comprehensive service. For any assistance, please contact our company headquarters:

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About the Document

History

Revision	Date	Author	Description
Draft	2018-09-28	Oscar LIU/ Reed Wang	Initial

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1 Introduction

This document defines EM12 module and describes its air interface and hardware interfaces which are connected with customers' applications.

This document can help customers to quickly understand the interface specifications, electrical and mechanical details, as well as other related information of EM12 module. To facilitate its application in different fields, reference design is also provided for customers' reference. Associated with application note and user guide, customers can use the module to design and set up mobile applications easily.

減少電磁波影響，請妥適使用.

The device could be used with a separation distance of 20cm to the human body.

Hereby, [Quectel Wireless Solutions Co., Ltd.] declares that the radio equipment type [EM12-G] is in compliance with Directive 2014/53/EU.
The full text of the EU declaration of conformity is available at the following internet address: http://www.quectel.com

FCC Regulations:

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

This device has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiated radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is

encouraged to try to correct the interference by one or more of the following measures:

-Reorient or relocate the receiving antenna.
-Increase the separation between the equipment and receiver.
-Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
-Consult the dealer or an experienced radio/TV technician for help.

Caution: Changes or modifications not expressly approved by the party responsible for compliance could void the user‘s authority to operate the equipment.

RF Exposure Information

This device complies with FCC radiation exposure limits set forth for an uncontrolled environment. In order to avoid the possibility of exceeding the FCC radio frequency exposure limits, human proximity to the antenna shall not be less than 20cm (8 inches) during normal operation.

ISED Notice

This device complies with Innovation, Science and Economic Development Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:
(1) this device may not cause interference, and
(2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:
(1) l'appareil ne doit pas produire de brouillage, et
(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en

This device complies with the Canadian ICES-003 Class B specifications.
CAN ICES-3(B)/ NMB-3(B)

ISED Radiation Exposure Statement

This device complies with RSS-102 radiation exposure limits set forth for an uncontrolled environment. In order to avoid the possibility of exceeding the ISED radio frequency exposure limits, human proximity to the antenna shall not be less than 20cm (8 inches) during normal operation.

Cet appareil est conforme aux limites d'exposition aux rayonnements de la CNR-102 définies pour un environnement non contrôlé. Afin d'éviter la possibilité de dépasser les limites d'exposition aux

fréquences radio de la CNR-102, la proximité humaine à l'antenne ne doit pas être inférieure à 20 cm (8 pouces) pendant le fonctionnement normal.

IMPORTANT NOTE:

This module is intended for OEM integrator. The OEM integrator is still responsible for the FCC compliance requirement of the end product, which integrates this module. 20cm minimum distance has to be able to be maintained between the antenna and the users for the host this module is integrated into. Under such configuration, the FCC radiation exposure limits set forth for an population/uncontrolled environment can be satisfied.

Any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate this equipment.

USERS MANUAL OF THE END PRODUCT:

In the users manual of the end product, the end user has to be informed to keep at least 20cm separation with the antenna while this end product is installed and operated. The end user has to be informed that the FCC radio-frequency exposure guidelines for an uncontrolled environment can be satisfied. The end user has to also be informed that any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate this equipment. If the size of the end product is smaller than 8x10cm, then additional FCC part 15.19 statement is required to be available in the users manual: This device complies with Part 15 of FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

LABEL OF THE END PRODUCT:

The final end product must be labeled in a visible area with the following " Contains Transmitter Module FCC ID: XMR201901EM12G ". If the size of the end product is larger than 8x10cm, then the following FCC part 15.19 statement has to also be available on the label: This device complies with Part 15 of FCC rules.

Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host device; otherwise, the host device must be labeled to display the Innovation, Science and Economic Development Canada certification number for the module, preceded by the words “Contains transmitter module IC: 10224A-201901EM12G”

1.1. Safety Information

The following safety precautions must be observed during all phases of the operation, such as usage, service or repair of any cellular terminal or mobile incorporating EM12-G module. Manufacturers of the cellular terminal should send the following safety information to users and operating personnel, and incorporate these guidelines into all manuals supplied with the product. If not so, Quectel assumes no liability for customers' failure to comply with these precautions.

	Full attention must be given to driving at all times in order to reduce the risk of an accident. Using a mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.
	Switch off the cellular terminal or mobile before boarding an aircraft. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. If the device offers an Airplane Mode, then it should be enabled prior to boarding an aircraft. Please consult the airline staff for more restrictions on the use of wireless devices on boarding the aircraft.
	Wireless devices may cause interference on sensitive medical equipment, so please be aware of the restrictions on the use of wireless devices when in hospitals, clinics or other healthcare facilities.
	Cellular terminals or mobiles operating over radio signals and cellular network cannot be guaranteed to connect in all possible conditions (for example, with unpaid bills or with an invalid (U)SIM card). When emergent help is needed in such conditions, please remember using emergency call. In order to make or receive a call, the cellular terminal or mobile must be switched on in a service area with adequate cellular signal strength.
	The cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.
	In locations with potentially explosive atmospheres, obey all posted signs to turn off wireless devices such as your phone or other cellular terminals. Areas with potentially explosive atmospheres include fuelling areas, below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles such as grain, dust or metal powders, etc.

2 Product Concept

2.1. General Description

EM12-G is a LTE/UMTS/HSPA+ wireless communication module with receive diversity. It provides data connectivity on LTE-FDD, LTE-TDD, DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA networks with standard PCI Express M.2 interface.

EM12-G supports embedded operating systems such as Windows CE, Linux and Android, and also provides GNSS1) and voice functionality2) to meet customers' specific application demands.

The following table shows the frequency bands and GNSS type of EM12-G module.

Table 1: Frequency Bands and GNSS Type of EM12-G Module

Mode	EM12-G
LTE-FDD (with Rx-diversity)	B1/B2/B3/B4/B5/B7/B8/B9/B12/B13/B14/B17/B18/B19/B20/B21[3)]/B25/B26/ B28/B29/B30/B32/B66;
LTE-TDD (with Rx-diversity)	B38/39/B40/B41
DL 2×CA	B1+3,5,18,19,20,26; B2+2,4,5,12,13,17,29,30,66; B3+3,5,7,8,19,20,28; B4+4(CA_4C only),5,12,13,17,29,30; B5+7,25,30,66; B7+7,20,28; B12+25,30; B13+66; B19+21[3)]; B20+B32; B25+25,26,41 B29+30; B38+38; B39+39 (CA_39C only); B39+39; B39+41

	B40+40 (CA_40C only); B41+41; B66+66 (CA_66C only);12,29,30,5; B2+B14;B14+B30;B14+B66; (Note: B29, B32 is only for secondary component carrier)
DL 3×CA	DL inter-band 3CA: 1+3+7, 1+3+19, 1+3+20, 1+3+5, 1+3+8, 1+3+28,1+7+20,1+3+5, 2+4+5, 2+4+13, 2+5+30, 2+12+30, 2+29+30 , 3+7+20, 3+7+28 , 3+7+8, 4+5+30, 4+12+30, 4+29+30 , 5+66+2, 13+66+2, 66+12+30,66+29+30,66+5+30; B2+B14+B66; DL 2 intra-band plus inter-band 3CA: 2+2+5, 2+2+13 , 3+3+7, 3+7+7, 3+3+20 , 3+3+28,3+3+1, 4+4+5, 4+4+13, 7+7+28, 5+66+66, 13+66+66, 66+66+2, B39+B39+B41; B39+B41+B41; B14+B66+B66 B25+B25+B26, B25+B41+B41 DL 3 intra-band 3CA: 40+40+40, 41+41+41, 66+66+66
UL CA	B3C;B7C;B38C;B40C;B41C;
WCDMA (with Rx-diversity)	B1/B2/B3/B4/B5/B8/B9/B19
GNSS [1)]	GPS, GLONASS, BeiDou, Galileo

NOTES

1. [1)] GNSS function is optional.
2. [2)] EM12-G contains **Telematics** version and **Data-only** version. **Telematics** version supports voice and data functions, while **Data-only** version only supports data function.
3. [3)]B21 band follow up will be developed

EM12-G can be applied in the following fields:

- Rugged Tablet PC and Laptop Computer
- Remote Monitor System
- Vehicle System

- Wireless POS System
- Smart Metering System
- Wireless Router and Switch
- Other Wireless Terminal Devices

2.2. Key Features

The following table describes the detailed features of EM12-G.

Table 2: Key Features of EM12-G

Feature	Details
Function Interface	PCI Express M.2 Interface
Power Supply	Supply voltage: 3.135V~4.4V Typical supply voltage: 3.7V
Transmitting Power	Class 3 (23dBm±2dB) for LTE-FDD bands Class 3 (23dBm±2dB) for LTE-TDD bands Class 3 (24dBm+1/-3dB) for WCDMA
LTE Features	Support up to LTE Cat 12 Support 1.4MHz to 20MHz RF bandwidth Support MIMO in DL direction ● FDD: Max 600Mbps (DL)/150Mbps (UL) ● TDD: Max 408Mbps (DL)/90Mbps (UL)
UMTS Features	Support 3GPP R8 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA Support QPSK, 16-QAM and 64-QAM modulation ● DC-HSDPA: Max 42Mbps (DL) ● HSUPA: Max 5.76Mbps (UL) ● WCDMA: Max 384Kbps (DL)/Max 384Kbps (UL)
Internet Protocol Features	Support PPP/QMI/NTP*/TCP*/UDP*/FTP*/HTTP*/PING*/HTTPS*/SMTP*/MMS*/FTPS*/SMTPS*/SSL* protocols Support the protocols PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) usually used for PPP connections
SMS	Text and PDU mode Point to point MO and MT SMS cell broadcast SMS storage: ME by default
(U)SIM Interfaces	Support (U)SIM card: 1.8V, 3.0V Include USIM1 and USIM2 interfaces Support Dual SIM Single Standby*

Audio Feature	Support one digital audio interface: PCM interface WCDMA: AMR/AMR-WB LTE: AMR/AMR-WB Support echo cancellation and noise suppression
PCM Interface	Used for audio function with external codec Support 16-bit linear data format Support long frame synchronization and short frame synchronization Support master and slave modes, but must be the master in long frame synchronization
USB Interface	Compliant with USB 3.0 and 2.0 specifications, with maximum transmission rates up to 5Gbps on USB 3.0 and 480Mbps on USB 2.0. Used for AT command communication, data transmission, firmware upgrade, software debugging, GNSS NMEA sentence output and voice over USB* Support USB serial drivers for: Windows 7/8/8.1/10, Windows CE 5.0/6.0/7.0*, Linux 2.6/3.x/4.1~4.14, Android 4.x/5.x/6.x/7.x
PCIE Interface*	Support PCIE interface, under development
Antenna Interface	Include main antenna, diversity antenna and GNSS antenna interfaces
Rx-diversity	Support LTE/WCDMA Rx-diversity
GNSS Features	Gen 9HT Lite of Qualcomm Protocol: NMEA 0183
AT Commands	Compliant with 3GPP TS 27.007, 27.005 and Quectel enhanced AT commands
Physical Characteristics	Size: (42.0±0.15)mm × (30.0±0.15)mm × (2.3±0.1)mm Weight: TBD
Temperature Range	Operation temperature range: -30°C~ +70°C [1)] Extended temperature range: -40°C~ +85°C [2)] Storage temperature range: -40°C ~ +90°C
Firmware Upgrade	USB 2.0 interface and DFOTA*
RoHS	All hardware components are fully compliant with EU RoHS directive

NOTES

1. [1)] Within operation temperature range, the module is 3GPP compliant.
2. [2)] Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to normal operating temperature levels, the module will meet 3GPP specifications again.
3. "*" means under development.

2.3. Functional Diagram

The following figure shows a block diagram of EM12-G.

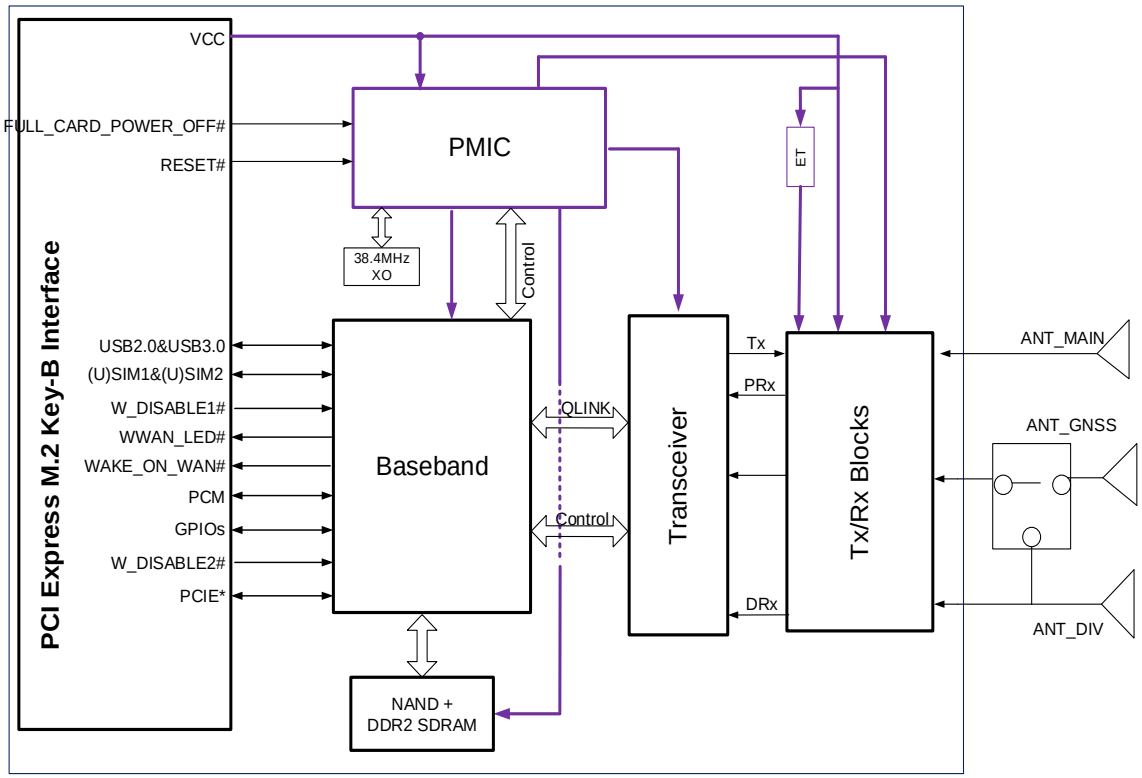


Figure 1: Functional Diagram

2.4. Evaluation Board

In order to help customers develop applications conveniently with EM12-G, Quectel supplies the evaluation board (M.2 EVB), USB to RS-232 converter cable, USB type-C cable, earphone, antenna and other peripherals to control or test the module. For more details, please refer to ***document [1]***.

3 Application Interfaces

The physical connections and signal levels of EM12-G comply with PCI Express M.2 specifications. This chapter mainly describes the definition and application of the following interfaces/signals/pins of EM12-G:

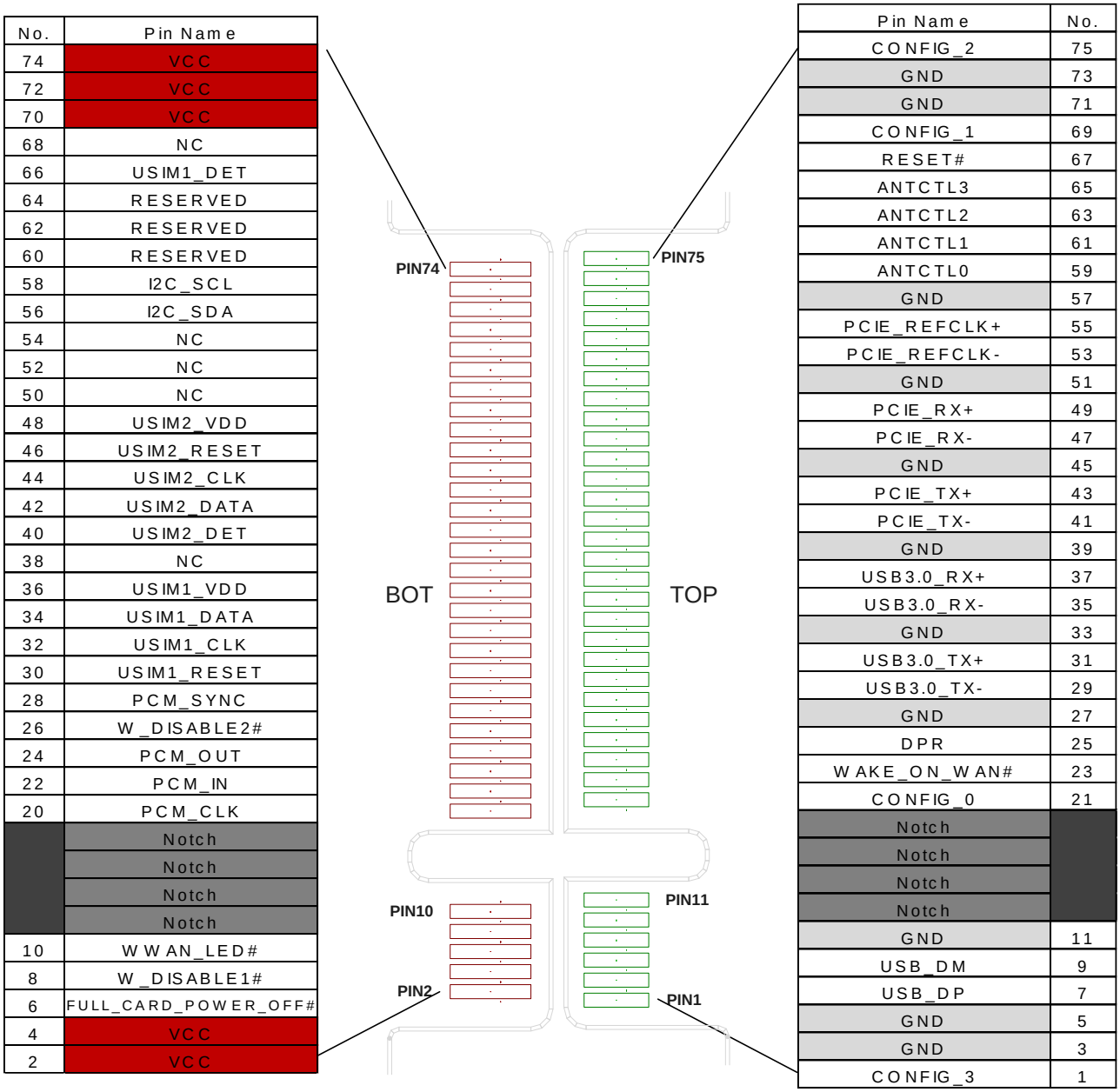
- Power supply
- (U)SIM interfaces
- USB interface
- PCIE interface*
- PCM and I2C interfaces
- Control and indicator signals
- Tunable antenna control interface*
- Configuration pins

NOTE

"*" means under development.

3.1. Pin Assignment

The following figure shows the pin assignment of EM12-G. The top side contains EM12-G module and antenna connectors.



No.	Pin Name
74	VCC
72	VCC
70	VCC
68	NC
66	USIM1_DET
64	RESERVED
62	RESERVED
60	RESERVED
58	I2C_SCL
56	I2C_SDA
54	NC
52	NC
50	NC
48	USIM2_VDD
46	USIM2_RESET
44	USIM2_CLK
42	USIM2_DATA
40	USIM2_DET
38	NC
36	USIM1_VDD
34	USIM1_DATA
32	USIM1_CLK
30	USIM1_RESET
28	PCM_SYNC
26	W_DISABLE2#
24	PCM_OUT
22	PCM_IN
20	PCM_CLK
	Notch
	Notch
	Notch
	Notch
10	WWAN_LED#
8	W_DISABLE1#
6	FULL_CARD_POWER_OFF#
4	VCC
2	VCC

Pin Name	No.
CONFIG_2	75
GND	73
GND	71
CONFIG_1	69
RESET#	67
ANTCTL3	65
ANTCTL2	63
ANTCTL1	61
ANTCTL0	59
GND	57
PCIE_REFCLK+	55
PCIE_REFCLK-	53
GND	51
PCIE_RX+	49
PCIE_RX-	47
GND	45
PCIE_TX+	43
PCIE_TX-	41
GND	39
USB3.0_RX+	37
USB3.0_RX-	35
GND	33
USB3.0_TX+	31
USB3.0_TX-	29
GND	27
DPR	25
WAKE_ON_WAN#	23
CONFIG_0	21
Notch	
Notch	
Notch	
Notch	
GND	11
USB_DM	9
USB_DP	7
GND	5
GND	3
CONFIG_3	1

Figure 2: Pin Assignment

3.2. Pin Description

The following tables show the pin definition and description of EM12-G on the 75-pin application.

Table 3: Definition of I/O Parameters

Type	Description
IO	Bidirectional
DI	Digital input
DO	Digital output
OD	Open drain
PI	Power input
PO	Power output

Table 4: Pin Description

Pin No.	M.2 Socket 2 WWAN Module Pinout	EM12-G Pin Name	I/O	Description	Comment
1	CONFIG_3	CONFIG_3		Not connected internally. EM12-G is configured as WWAN-USB 3.0.	
2	3.3V	VCC	PI	Power supply	Vmin=3.135V Vnorm=3.7V Vmax=4.4V
3	GND	GND		Ground	
4	3.3V	VCC	PI	Power supply	Vmin=3.135V Vnorm=3.7V Vmax=4.4V
5	GND	GND		Ground	
6	FULL_CARD_ POWER_OFF#	FULL_CARD_ POWER_OFF#	DI	A signal to control power-on/-off of the module. When it is at low level, the module powers off. When it is at high level, the module powers on.	Pulled down internally

7	USB_D+	USB_DP	IO	USB 2.0 differential data bus (+)	
8	W_DISABLE1#	W_DISABLE1#	DI	Airplane mode control. Active low.	1.8V/3.3V power domain
9	USB_D-	USB_DM	IO	USB 2.0 differential data bus (-)	
10	GPIO_9	WWAN_LED#	OD	It is an open collector and active low signal. It allows the module to provide RF status indication via LED devices provided by the system.	3.3V power domain
11	GND	GND		Ground	
12	Key	Notch		Notch	
13	Key	Notch		Notch	
14	Key	Notch		Notch	
15	Key	Notch		Notch	
16	Key	Notch		Notch	
17	Key	Notch		Notch	
18	Key	Notch		Notch	
19	Key	Notch		Notch	
20	GPIO_5 (AUDIO_0)	PCM_CLK	IO	PCM data bit clock. In master mode, it is an output signal. In slave mode, it is an input signal. If unused, keep it open.	1.8V power domain
21	CONFIG_0	CONFIG_0		Connected to GND internally. EM12-G is configured as WWAN-USB 3.0.	
22	GPIO_6 (AUDIO_1)	PCM_IN	DI	PCM data input	1.8V power domain
23	GPIO_11 (WOWWAN#)	WAKE_ON_ WAN#	OD	A signal to wake up the host. It is an open collector and active low signal.	1.8V power domain
24	GPIO_7 (AUDIO_2)	PCM_OUT	DO	PCM data output	1.8V power domain
25	DPR	DPR	DI	Dynamic power reduction. High level by default.	1.8V power domain
26	GPIO_10 (W_DISABLE2#)	W_DISABLE2#*	DI	GNSS enable control. Active low.	1.8V/3.3V power domain
27	GND	GND		Ground	
28	GPIO_8	PCM_SYNC	IO	PCM data frame synchronization	1.8V power

	(AUDIO_3)			signal	domain
29	USB3.0-TX-	USB3.0_TX-	DO	USB 3.0 transmit data (-)	
30	UIM-RESET	USIM1_RESET	DO	(U)SIM1 card reset	1.8V/3.0V power domain
31	USB3.0-TX+	USB3.0_TX+	DO	USB 3.0 transmit data (+)	
32	UIM-CLK	USIM1_CLK	DO	(U)SIM1 card clock	1.8V/3.0V power domain
33	GND	GND		Ground	
34	UIM-DATA	USIM1_DATA	IO	(U)SIM1 card data	Pulled up to USIM2_VDD internally
35	USB3.0-RX-	USB3.0_RX-	DI	USB 3.0 receive data (-)	
36	UIM-PWR	USIM1_VDD	PO	Power supply for (U)SIM1 card	1.8V/3.0V power domain
37	USB3.0-RX+	USB3.0_RX+	DI	USB 3.0 receive data (+)	
38	N/C	NC		NC	
39	GND	GND		Ground	
40	GPIO_0 (SIM_DET2)	USIM2_DET	DI	(U)SIM2 card insertion detection	Pulled up internally
41	PETn0	PCIE_TX-	DO	PCIE transmit data (-)	
42	GPIO_1 (SIM_DAT2)	USIM2_DATA	IO	(U)SIM2 card data	Pulled up to USIM2_VDD internally
43	PETp0	PCIE_TX+	DO	PCIE transmit data (+)	
44	GPIO_2 (SIM_CLK2)	USIM2_CLK	DO	(U)SIM2 card clock	1.8V/3.0V power domain
45	GND	GND		Ground	
46	GPIO_3 (SIM_RST2)	USIM2_RESET	DO	(U)SIM2 card reset	1.8V/3.0V power domain
47	PERn0	PCIE_RX-	DI	PCIE receive data (-)	
48	GPIO_4 (SIM_PWR2)	USIM2_VDD	PO	Power supply for (U)SIM2 card	1.8V/3.0V power domain
49	PERp0	PCIE_RX+	DI	PCIE receive data (+)	
50	PRRST#	PCIE_RST_N	DI	PCIE reset. Active low.	3.3V power domain

51	GND	GND		Ground	
52	CLKREQ#	PCIE_CLKREQ_N	IO	PCIE clock request. Active low.	3.3V power domain
53	REFCLKn	PCIE_REFCLK-	AI	PCIE reference clock(-)	
54	PEWAKE#	PCIE_WAKE_N	IO	PCIE wake on host. Active low.	3.3V power domain
55	REFCLKp	PCIE_REFCLK+	AI	PCIE reference clock(+)	
56	N/C	I2C_DATA	IO	I2C serial data. Used for external codec.	
57	GND	GND		Ground	
58	N/C	I2C_CLK	DO	I2C serial clock. Used for external codec.	
59	ANTCTL0	ANTCTL0*	DO	Tunable antenna control.	1.8V power domain
60	COEX3	RESERVED		Reserved	
61	ANTCTL1	ANTCTL1*	DO	Tunable antenna control.	1.8V power domain
62	COEX2	RESERVED		Reserved	
63	ANTCTL2	ANTCTL2*	DO	Tunable antenna control.	1.8V power domain
64	COEX1	RESERVED		Reserved	
65	ANTCTL3	ANTCTL3*	DO	Tunable antenna control.	1.8V power domain
66	SIM_DETECT	USIM1_DET	DI	(U)SIM1 card insertion detection	Pulled up internally
67	RESET#	RESET#	DI	System reset. Active low.	
68	SUSCLK (32kHz)	NC		NC	
69	CONFIG_1	CONFIG_1		Connected to GND internally. EM12-G is configured as WWAN-USB 3.0.	
70	3.3V	VCC	PI	Power supply	Vmin=3.135V Vnorm=3.7V Vmax=4.4V
71	GND	GND		Ground	
72	3.3V	VCC	PI	Power supply	Vmin=3.135V Vnorm=3.7V Vmax=4.4V

73	GND	GND		Ground	
74	3.3V	VCC	PI	Power supply	Vmin=3.135V Vnorm=3.7V Vmax=4.4V
75	CONFIG_2	CONFIG_2		Not connected internally. EM12-G is configured as WWAN-USB 3.0.	

NOTES

1. Keep all NC, reserved and unused pins unconnected.
2. "*" means under development.

3.3. Power Supply

The following table shows pin definition of VCC pins and ground pins.

Table 5: Definition of VCC and GND Pins

Pin No.	Pin Name	I/O	Power Domain	Description
2, 4, 70, 72, 74	VCC	PI	3.135V~4.4V	3.7V typical DC supply
3, 5, 11, 27, 33, 39, 45, 51, 57, 71, 73	GND			Ground

3.3.1. Decrease Voltage Drop

The power supply range of the module is from 3.135V to 4.4V. Please make sure that the input voltage will never drop below 3.135V, otherwise the module will be powered off automatically. The following figure shows the maximum voltage drop during radio transmission in 3G and 4G networks.

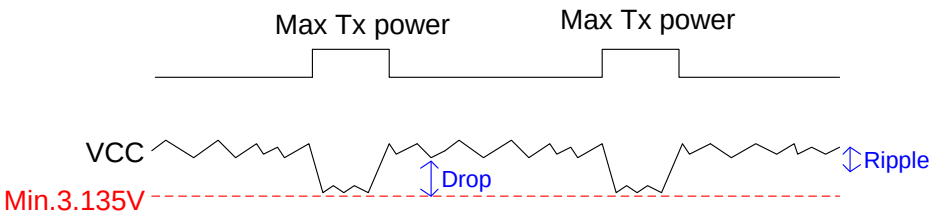


Figure 3: Power Supply Limits during Radio Transmission

To decrease voltage drop, a bypass capacitor of about 220μF with low ESR (ESR=0.7Ω) should be used, and a multi-layer ceramic chip capacitor (MLCC) array should also be reserved due to its ultra-low ESR. It is recommended to use three ceramic capacitors (100nF, 33pF, 10pF) for composing the MLCC array, and place these capacitors close to VCC pins. The main power supply from an external application has to be a single voltage source. The width of VCC trace should be no less than 2mm. In principle, the longer the VCC trace is, the wider it will be.

In addition, in order to get a stable power source, it is recommended to use a zener diode with reverse zener voltage of 5.1V and dissipation power more than 0.5W. The following figure shows a reference circuit of VCC.

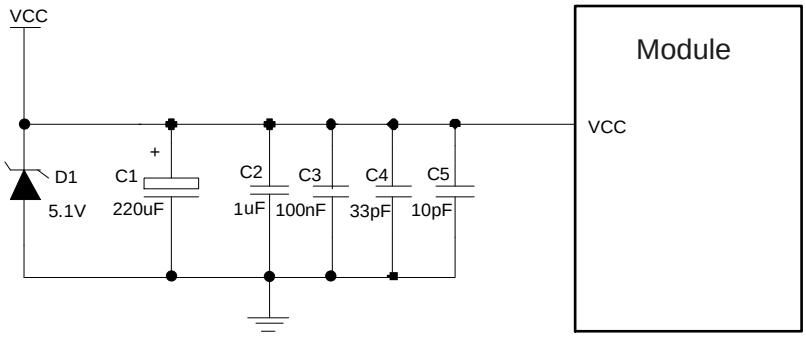


Figure 4: Reference Circuit of VCC

3.3.2. Reference Design for Power Supply

Power design for the module is very important, as the performance of the module largely depends on the power source. The power supply is capable of providing sufficient current up to 2A at least. If the voltage drop between the input and output is not too high, it is suggested that an LDO should be used to supply power for the module. If there is a big voltage difference between the input source and the desired output (VCC), a buck converter is preferred to be used as the power supply.

The following figure shows a reference design for +5V input power source. The typical output of the power supply is about 3.7V and the maximum load current is 3A.

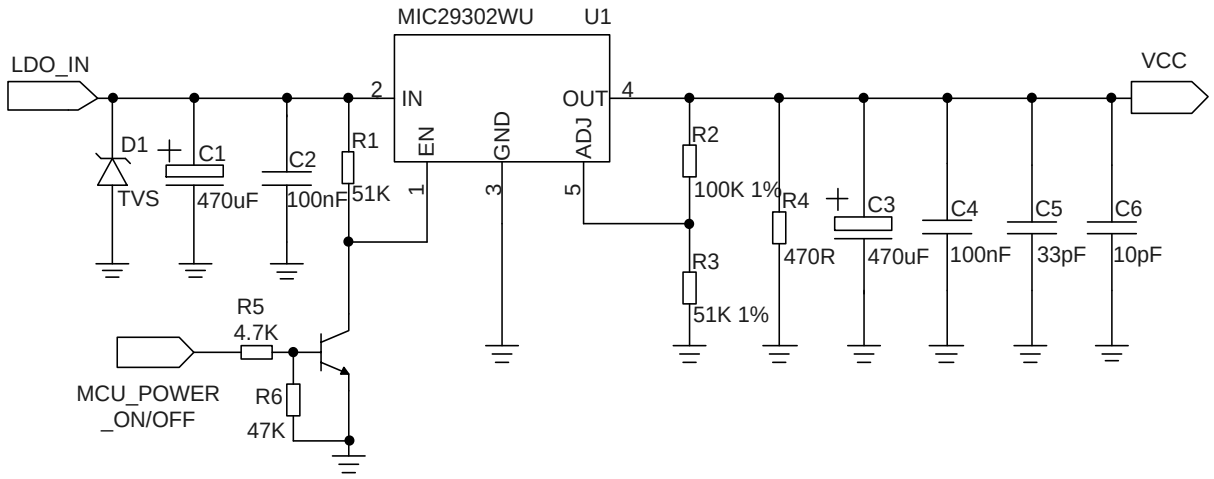


Figure 5: Reference Design of Power Supply

NOTE

In order to avoid damages to the internal flash, please do not switch off the power supply directly when the module is working. It is suggested that the power supply can be cut off after pulling down FULL_CARD_POWER_OFF# for about 100ms.

3.4. Turn on and off Scenarios

3.4.1. Turn on the Module

Driving the FULL_CARD_POWER_OFF# pin to a high level will power on the module. The following table shows the definition of FULL_CARD_POWER_OFF#.

Table 6: Definition of FULL_CARD_POWER_OFF# Pin

Pin Name	Pin No.	Description	DC Characteristics	Comment
FULL_CARD_POWER_OFF#	6	A signal to control power-on/-off of the module. When it is at low level, the module powers off. When it is at high level, the module powers on.	V_{IH}max=4.4V V_{IH}min=0.7V V_{IL}max=0.5V	Pulled down internally.

3.4.1.1. Turn on the Module Through GPIO Controlled FULL_CARD_POWER_OFF#

It is recommended to use a GPIO from host to control FULL_CARD_POWER_OFF#. A simple reference circuit is illustrated in the following figure.

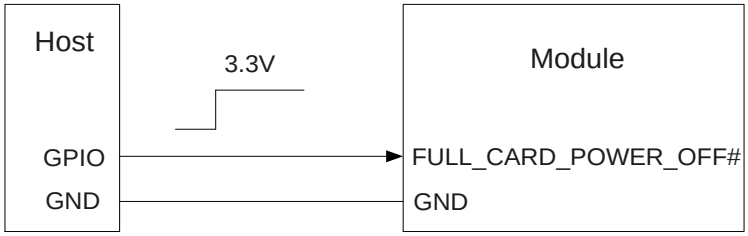


Figure 6: Turn on the Module Through GPIO Controlled FULL_CARD_POWER_OFF#

3.4.1.2. Turn on the Module Automatically

If FULL_CARD_POWER_OFF# is pulled up to 3.3V with a 5kΩ~10kΩ resistor, the module will be powered on automatically when the power supply for VCC is applied, and will be powered off when the power supply is removed.

A reference circuit is shown in the following figure.

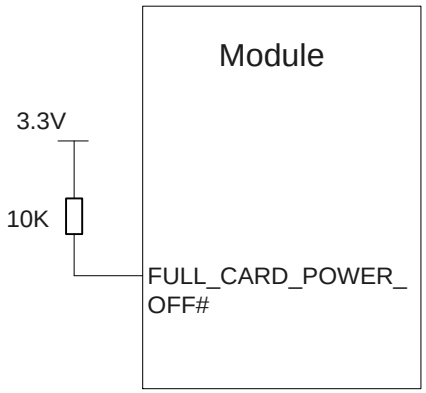


Figure 7: Turn on the Module Automatically

The turn on scenario is illustrated in the following figure.

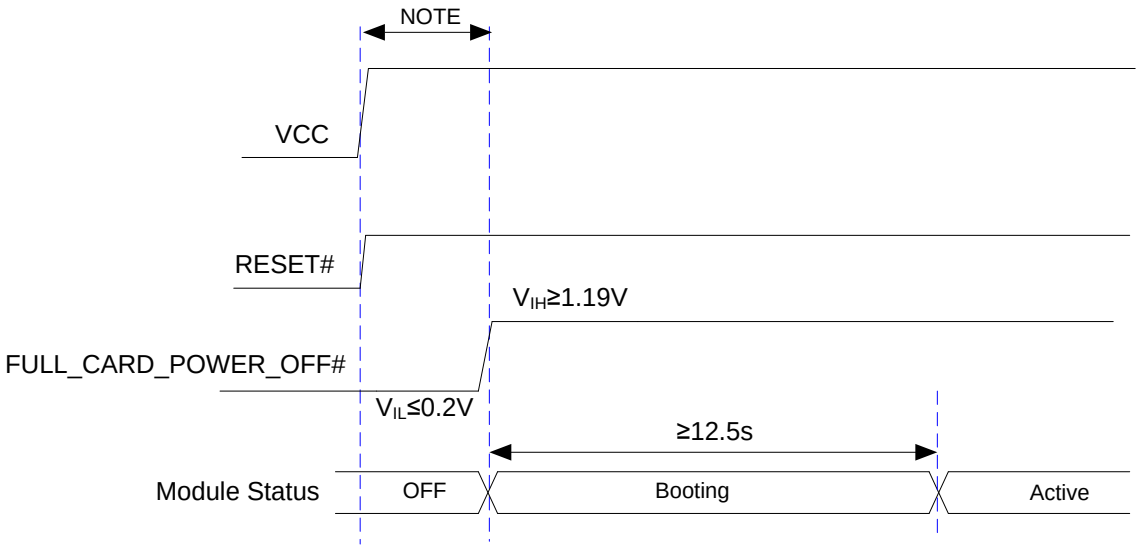


Figure 8: Timing of Turning on Module

NOTE

Please make sure that VCC is stable before pulling down FUL_CARD_POWER_OFF# pin. The time between them is no less than 30ms.

3.4.2. Turn off the Module

3.4.2.1. Turn off the Module Through FULL_CARD_POWER_OFF#

Driving the FULL_CARD_POWER_OFF# pin to low will turn off the module.

The power-down scenario is illustrated in the following figure.

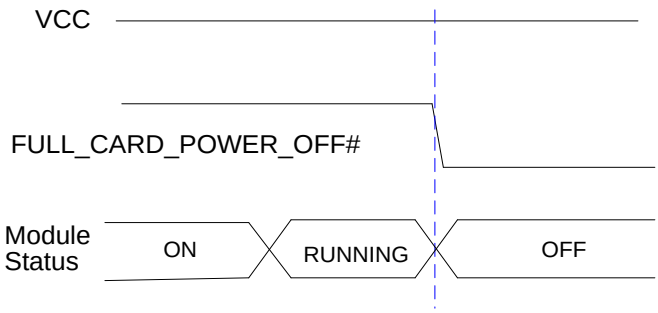


Figure 9: Timing of Turning off the Module Through FULL_CARD_POWER_OFF#

3.4.2.2. Turn off the Module via AT Command

The module can also be turned off by **AT+QPOWD** command. For more details about the command, please refer to ***document [2]***.

3.5. Reset the Module

The RESET# pin is used to reset the module. The module can be reset by driving RESET# to a low level voltage for 250ms~600ms.

Table 7: RESET# Pin Definition

Pin Name	Pin No.	Description	DC Characteristics	Comment
RESET#	67	Reset the module	V_{IH}max=2.1V V_{IH}min=1.3V V_{IL}max=0.5V	

An open collector/collector driver or button can be used to control the RESET# pin.

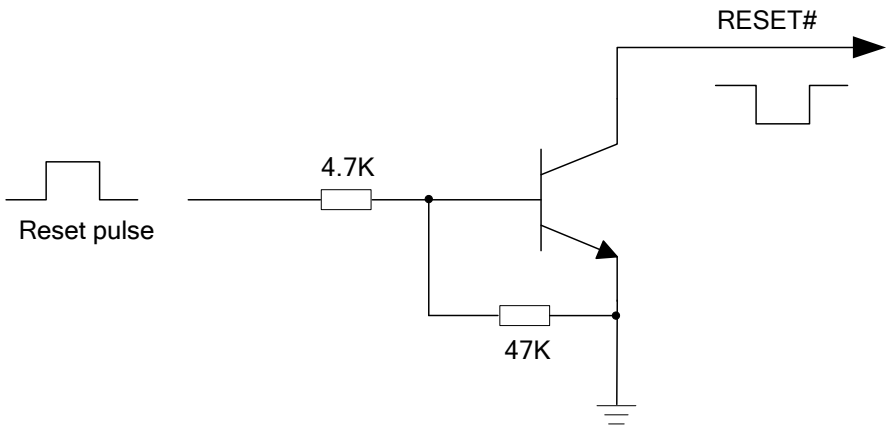


Figure 10: Reference Circuit of RESET# by Using Driving Circuit

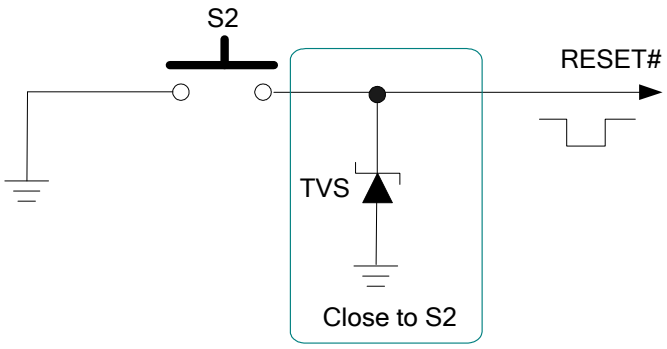


Figure 11: Reference Circuit of RESET# by Using Button

The reset scenario is illustrated in the following figure.

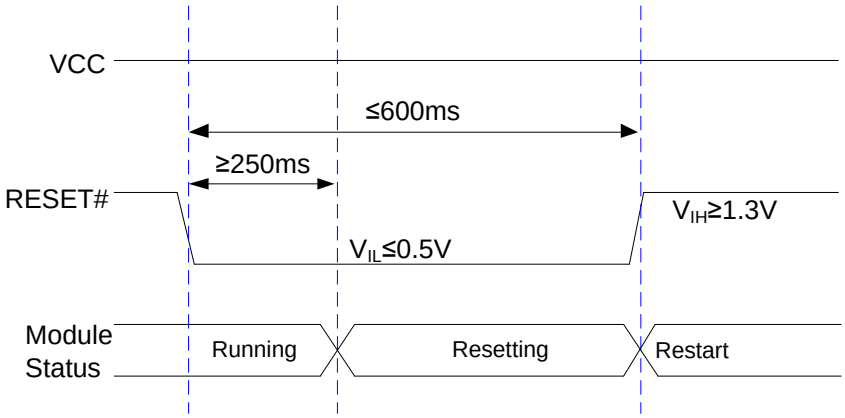


Figure 12: Timing of Resetting Module

NOTE

Please ensure that there is no large capacitance on RESET# pin.

3.6. (U)SIM Interfaces

The (U)SIM interface circuitry meets ETSI and IMT-2000 requirements. Both 1.8V and 3.0V (U)SIM cards are supported, and Dual SIM Single Standby* function is supported.

Table 8: Pin Definition of (U)SIM Interfaces

Pin Name	Pin No.	I/O	Description	Comment
USIM1_VDD	36	PO	Power supply for (U)SIM1 card	Either 1.8V or 3.0V is supported by the module automatically.
USIM1_DATA	34	IO	Data signal of (U)SIM1 card	
USIM1_CLK	32	DO	Clock signal of (U)SIM1 card	
USIM1_RESET	30	DO	Reset signal of (U)SIM1 card	
USIM1_DET	66	DI	(U)SIM1 card insertion detection. Active high.	Pulled up internally. When (U)SIM1 card is present, it is at high level. When (U)SIM1 card is absent, it is at low level.
USIM2_VDD	48	PO	Power supply for (U)SIM2 card	Either 1.8V or 3.0V is supported by the module automatically.
USIM2_DATA	42	IO	Data signal of (U)SIM2 card	
USIM2_CLK	44	DO	Clock signal of (U)SIM2 card	
USIM2_RESET	46	DO	Reset signal of (U)SIM2 card	
USIM2_DET	40	DI	(U)SIM2 card insertion detection. Active high.	Pulled up internally. When (U)SIM2 card is present, it is at high level. When (U)SIM2 card is absent, it is at low level.

EM12-G supports (U)SIM card hot-plug via the USIM_DET pin, which is a level trigger pin. The USIM_DET is normally short-circuited to ground when (U)SIM card is not inserted. When the (U)SIM card is inserted, the USIM_DET will change from low to high level. The rising edge will indicate insertion of the (U)SIM card. When the (U)SIM card is removed, the USIM_DET will change from high to low level. This falling edge will indicate the absence of the (U)SIM card.

The following figure shows a reference design of (U)SIM interface with normally short-circuited (U)SIM card connector.

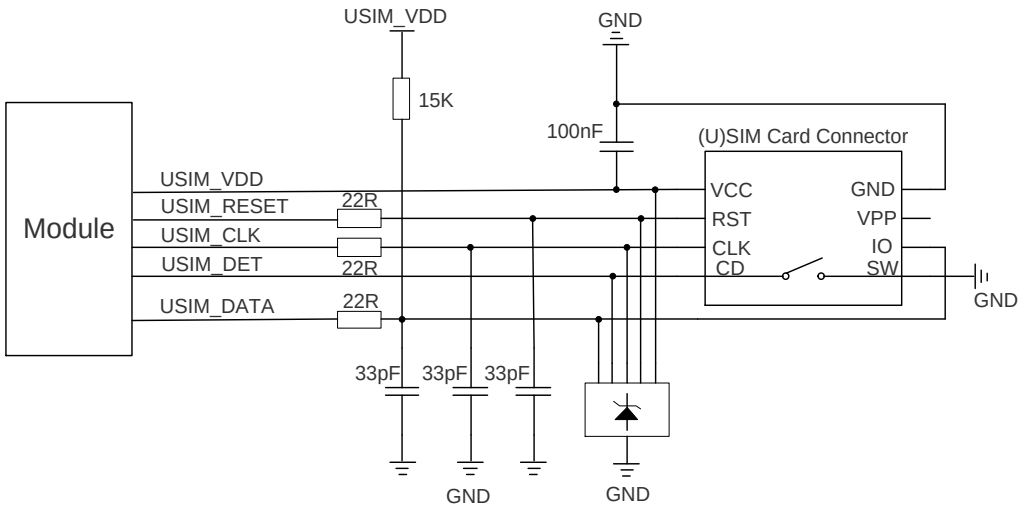


Figure 13: Reference Circuit of Normally Short-Circuited (U)SIM Card Connector

Normally Short-Circuited (U)SIM Card Connector:

- When the (U)SIM is absent, CD is short-circuited to SW and USIM_DET is at low level.
- When the (U)SIM is inserted, CD is open to SW and USIM_DET is at high level.

The following figure shows a reference design of (U)SIM interface with normally open (U)SIM card connector.

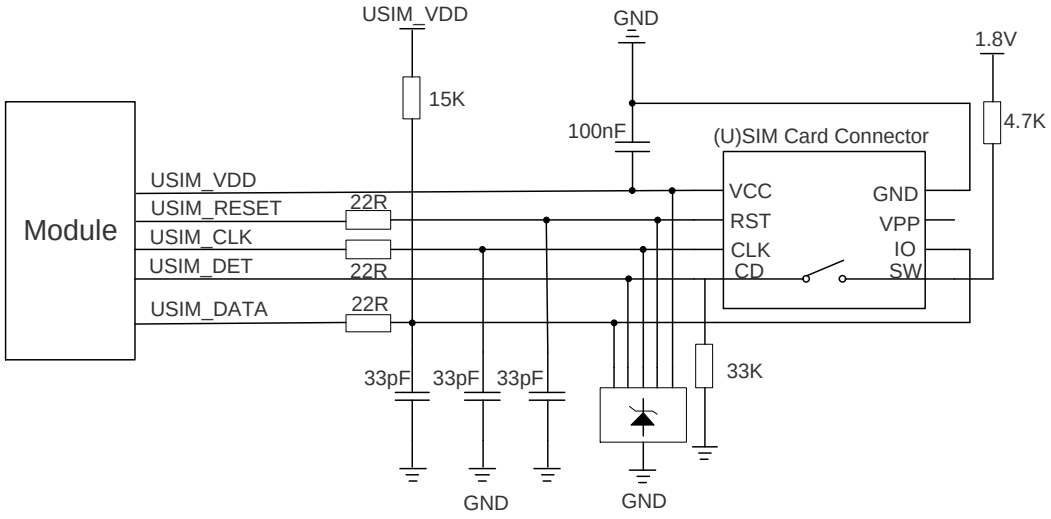


Figure 14: Reference Circuit of Normally Open (U)SIM Card Connector

Normally Open (U)SIM Card Connector:

- When the (U)SIM is absent, CD is open to SW and USIM_DET is at low level.
- When the (U)SIM is inserted, CD is short-circuited to SW and USIM_DET is at high level.

If (U)SIM card detection function is not needed, please keep USIM_DET unconnected. A reference circuit for (U)SIM card interface with a 6-pin (U)SIM card connector is illustrated in the following figure.

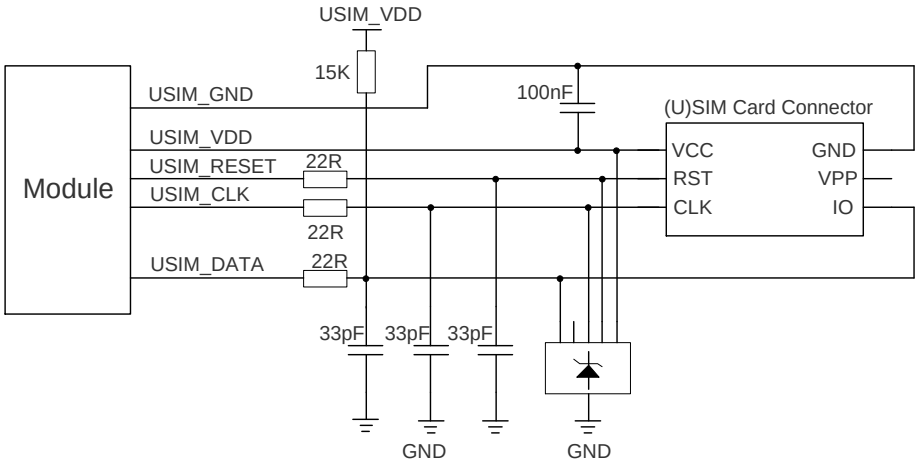


Figure 15: Reference Circuit of a 6-Pin (U)SIM Card Connector

In order to enhance the reliability and availability of the (U)SIM card in customers' applications, please follow the criteria below in (U)SIM circuit design:

- Keep placement of (U)SIM card connector as close as possible to the module. Keep the trace length as less than 200mm as possible.
- Keep (U)SIM card signals away from RF and VCC traces.
- Assure the ground between the module and the (U)SIM card connector short and wide. Keep the trace width of ground and USIM_VDD no less than 0.5mm to maintain the same electric potential.
- To avoid cross-talk between USIM_DATA and USIM_CLK, keep them away from each other and shield them with surrounded ground.
- In order to offer good ESD protection, it is recommended to add a TVS diode array with parasitic capacitance not exceeding 10pF. The 22Ω resistors should be added in series between the module and the (U)SIM card connector so as to suppress EMI spurious transmission and enhance ESD protection. The 33pF capacitors are used to filter out RF interference. Please note that the (U)SIM peripheral circuit should be close to the (U)SIM card connector.
- The pull-up resistor on USIM_DATA line can improve anti-jamming capability when long layout trace and sensitive occasion are applied, and should be placed close to the (U)SIM card connector.

NOTE

"*" means under development.

3.7. USB Interface

EM12-G provides one integrated Universal Serial Bus (USB) interface which complies with the USB 3.0/2.0 specifications and supports super speed (5Gbps) on USB 3.0, high speed (480 Mbps) and full speed (12 Mbps) modes on USB 2.0. The USB interface is used for AT command communication, data transmission, GNSS NMEA output, software debugging, firmware upgrade and voice over USB*.

The following table shows the pin definition of USB interface.

Table 9: Pin Definition of USB Interface

Pin No.	Pin Name	I/O	Description	Comment
7	USB_DP	IO	USB 2.0 differential data bus (+)	Require differential impedance of 90Ω
9	USB_DM	IO	USB 2.0 differential data bus (-)	
29	USB3.0_TX-	DO	USB 3.0 transmit data (-)	Require differential impedance of 90Ω
31	USB3.0_TX+	DO	USB 3.0 transmit data (+)	
35	USB3.0_RX-	DI	USB 3.0 receive data (-)	Require differential impedance of 90Ω
37	USB3.0_RX+	DI	USB 3.0 receive data (+)	

For more details about the USB 2.0 & 3.0 specifications, please visit http://www.usb.org/home.

The USB interface is recommended to be reserved for firmware upgrade in customers' designs. The following figure shows a reference circuit of USB 2.0 & USB 3.0 interface.

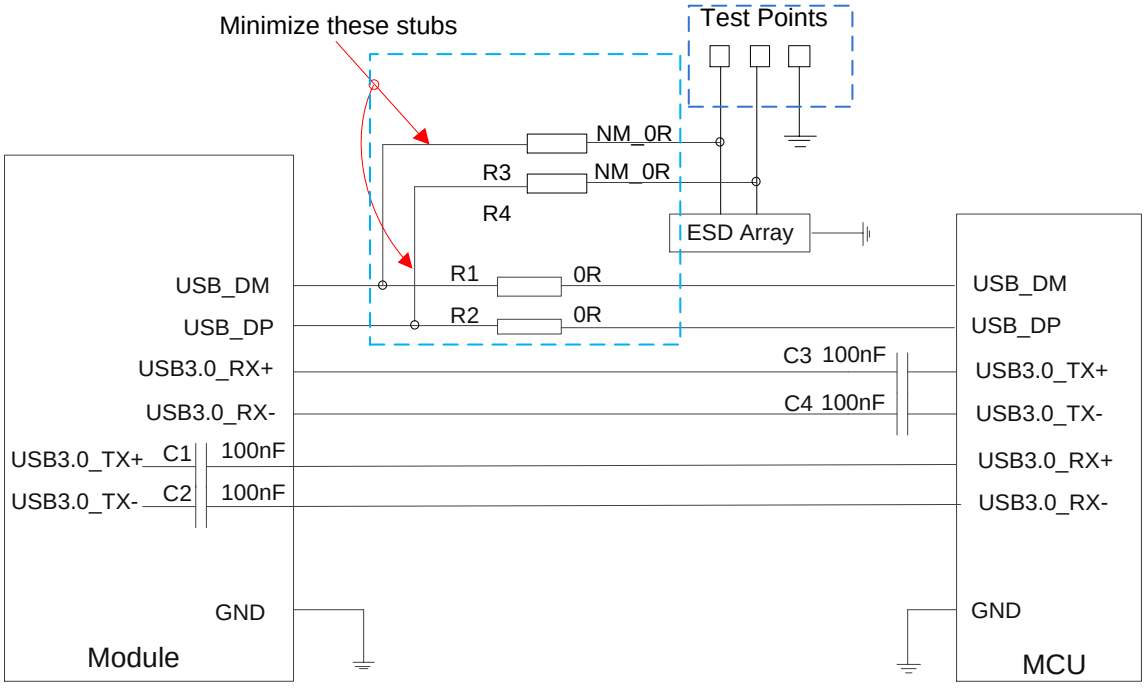


Figure 16: Reference Circuit of USB 2.0 & 3.0 Interface

In order to ensure the integrity of USB 2.0 & 3.0 data line signal, R1/R2/R3/R4 components must be placed close to the module, capacitors C1 and C2 have been placed inside the module, capacitors C3 and C4 must be placed close to the MCU, and these components should be placed close to each other.

In order to ensure the USB interface design corresponding with USB 2.0 & 3.0 specifications, please comply with the following principles:

- It is important to route the USB 2.0 & 3.0 signal traces as differential pairs with total grounding.
  1) For USB 2.0 routing traces, the trace impedance of the differential pair should be 90Ω, and the trace length difference between the differential pair should be less than 2mm.
  2) For USB 3.0 routing traces, the trace impedance of Tx and Rx differential pairs should be 90Ω, and the trace length difference between Tx and Rx differential pairs should be less than 0.7mm.
- Do not route signal traces under crystals, oscillators, magnetic devices or RF signal traces. It is important to route the USB 2.0 & 3.0 differential traces in inner-layer with ground shielding on not only upper and lower layers but also right and left sides.
- If USB connector is used, please keep the ESD protection components as close as possible to the USB connector. Pay attention to the influence of junction capacitance of ESD protection components on USB 2.0 & 3.0 data lines. The capacitance value of ESD protection components should be less than 2.0pF for USB 2.0, and less than 0.4pF for USB 3.0.
- If possible, reserve a 0R resistor on USB_DP and USB_DM lines, respectively.

NOTE

"*" means under development.

3.8. PCIE Interface

Under development

3.9. PCM and I2C Interfaces

EM12-G supports audio communication via Pulse Code Modulation (PCM) digital interface and I2C interface.

The PCM interface supports the following modes:

- Primary mode (short frame synchronization, works as both master and slave)
- Auxiliary mode (long frame synchronization, works as master only)

In primary mode, the data is sampled on the falling edge of the PCM_CLK and transmitted on the rising edge. The PCM_SYNC falling edge represents the MSB. In this mode, the PCM interface supports 256kHz, 512kHz, 1024kHz or 2048kHz PCM_CLK at 8kHz PCM_SYNC, and also supports 4096kHz PCM_CLK at 16kHz PCM_SYNC.

In auxiliary mode, the data is sampled on the falling edge of the PCM_CLK and transmitted on the rising edge. The PCM_SYNC rising edge represents the MSB. In this mode, PCM interface operates with a 256kHz PCM_CLK and an 8kHz, 50% duty cycle PCM_SYNC only.

EM12-G supports 16-bit linear data format. The following figures show the primary mode's timing relationship with 8kHz PCM_SYNC and 2048kHz PCM_CLK, as well as the auxiliary mode's timing relationship with 8kHz PCM_SYNC and 256kHz PCM_CLK.

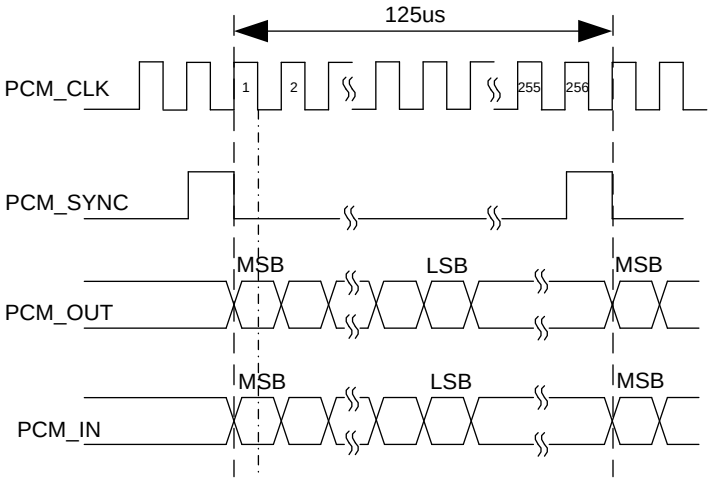


Figure 17: Primary Mode Timing

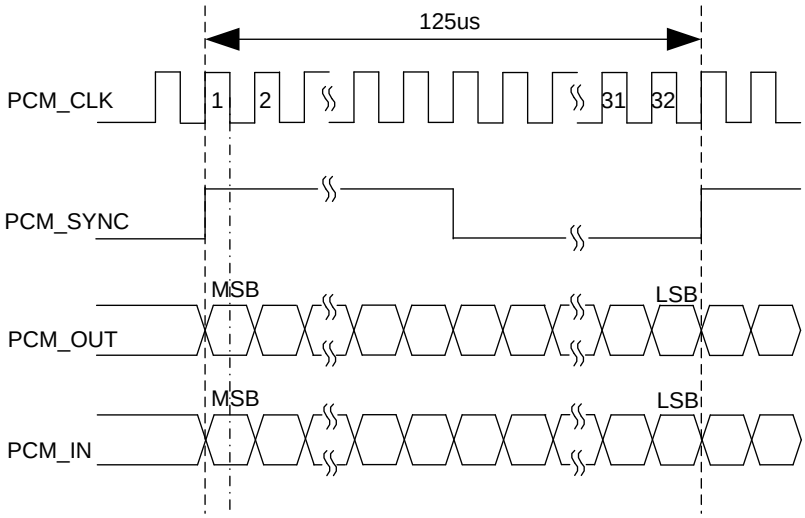


Figure 18: Auxiliary Mode Timing

The following table shows the pin definition of PCM and I2C interfaces which can be applied on audio codec design.

Table 10: Pin Definition of PCM and I2C Interfaces

Pin Name	Pin No.	I/O	Description	Comment
PCM_IN	22	DI	PCM data input	1.8V power domain.
PCM_OUT	24	DO	PCM data output	1.8V power domain.

PCM_SYNC	28	IO	PCM data frame synchronization signal	1.8V power domain.
PCM_CLK	20	IO	PCM data bit clock	1.8V power domain. In master mode, it is an output signal. In slave mode, it is an input signal. If unused, keep it open.
I2C_SCL	58	DO	I2C serial clock	Used for external codec. Require an external pull-up to 1.8V.
I2C_SDA	56	IO	I2C serial data	

The clock and mode can be configured by AT command, and the default configuration is master mode using short frame synchronization format with 2048kHz PCM_CLK and 8kHz PCM_SYNC. Please refer to ***document [2]*** for details about **AT+QDAI** command.

The following figure shows a reference design of PCM interface with an external codec IC.

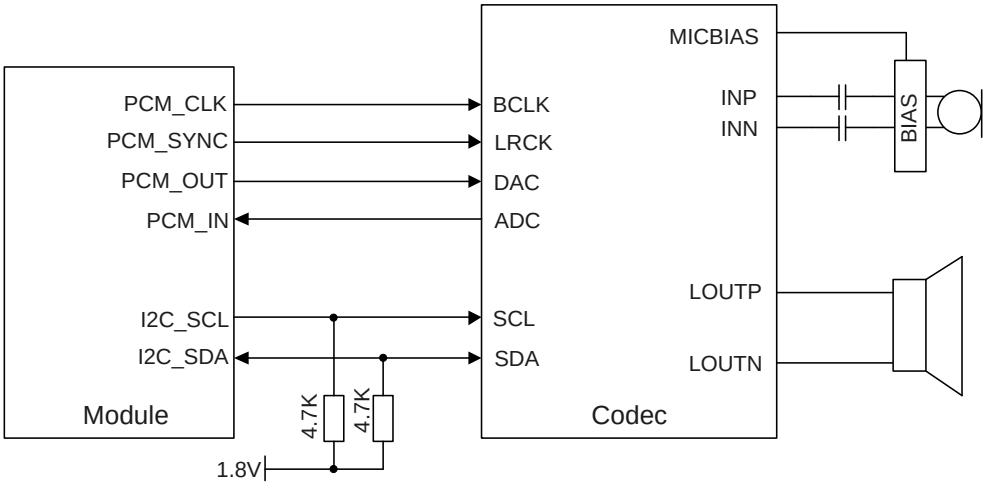


Figure 19: Reference Circuit of PCM Application with Audio Codec

NOTES

1. It is recommended to reserve an RC (R=22Ω, C=22pF) circuit on the PCM lines, especially for PCM_CLK.
2. EM12-G works as a master device pertaining to I2C interface.

3.10. Control and Indicator Signals

The following table shows the pin definition of control and indicator signals.

Table 11: List of Control and Indicator Signals

NOTE	Pin Name	I/O	Power Domain	Description
10	WWAN_LED#	OD	3.3V	It is an open collector and active low signal. It is used to indicate the RF status of the module.
23	WAKE_ON_WAN#	OD	1.8V	A signal to wake up the host. It is an open collector and active low signal.
8	W_DISABLE1#	DI	1.8V/3.3V	Airplane mode control. Active low.
26	W_DISABLE2#*	DI	1.8V/3.3V	GNSS enable control. Active low.
25	DPR	DI	1.8V	Dynamic power reduction. High level by default.

"*" means under development.

3.10.1. W_DISABLE1# Signal

EM12-G provides a W_DISABLE1# signal to disable or enable airplane mode through hardware operation. The W_DISABLE1# pin is pulled up by default. Driving it to low level will let the module enter into airplane mode.

In airplane mode, the RF function will be disabled. The RF function can also be enabled or disabled through software AT commands. The following table shows the RF function status of the module.

Table 12: RF Function Status

W_DISABLE1# Level	AT Commands	RF Function Status
High Level	**AT+CFUN=1**	Enabled
High Level	**AT+CFUN=0** **AT+CFUN=4**	Disabled
Low Level	**AT+CFUN=0** **AT+CFUN=1** **AT+CFUN=4**	Disabled

3.10.2. WWAN_LED# Signal

The WWAN_LED# signal is used to indicate the RF status of the module, and its typical current consumption is up to 40mA.

In order to reduce the current consumption of the LED, a resistor must be placed in series with the LED, as illustrated in the figure below. The LED is ON when the WWAN_LED# signal is at a low voltage level.

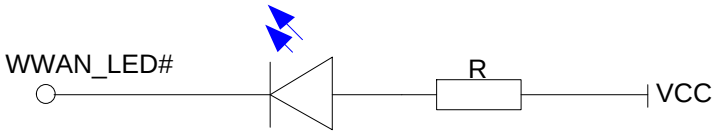


Figure 20: WWAN_LED# Signal Reference Circuit Diagram

The following table shows the RF status indicated by WWAN_LED# signal.

Table 13: Network Status Indications of WWAN_LED# Signal

WWAN_LED# Level	Description
Low Level (LED ON)	RF function is turned on
High Level (LED OFF)	RF function is turned off if any of the following circumstances occurs: ● The (U)SIM card is not powered ● W_DISABLE1# signal is at low level (airplane mode enabled). ● **AT+CFUN=4** (RF function disabled)

3.10.3. WAKE_ON_WAN# Signal

The WAKE_ON_WAN# signal is an open collector signal, which requires a pull-up resistor on the host. When a URC returns, a 1s low level pulse signal will be outputted to wake up the host. The module operation status indicated by WAKE_ON_WAN# is shown as below.

Table 14: State of the WAKE_ON_WAN# Signal

WAKE_ON_WAN# State	Module Operation Status
Output a 1s low level pulse signal	Call/SMS/Data is incoming (to wake up the host)
Always at high level	Idle/Sleep

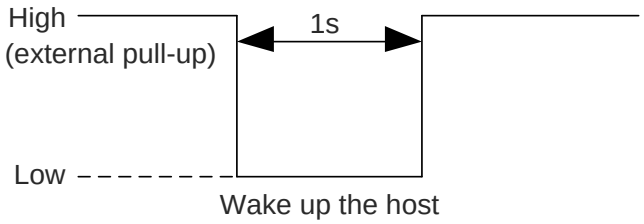


Figure 21: WAKE_ON_WAN# Behavior

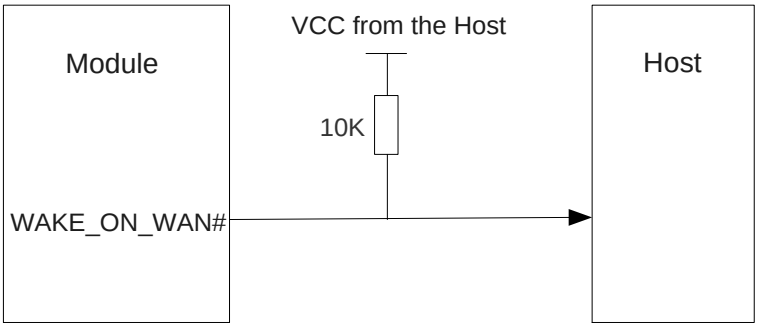


Figure 22: WAKE_ON_WAN# Signal Reference Circuit Design

3.10.4. DPR Signal

EM12-G provides a DPR (Dynamic Power Reduction) signal for body SAR (Specific Absorption Rate) detection. The signal is sent by a host system proximity sensor to EM12-G module to provide an input trigger which will reduce the output power in the radio transmission.

Table 15: Function of the DPR Signal

DPR Level	Function
High/Floating	Max transmitting power will NOT be backed off
Low	Max transmitting power will be backed off by executing **AT+QCFG="sarcfg"** command

NOTE

Please refer to ***document [2]*** for more details about **AT+QCFG="sarcfg"** command.

3.11. Tunable Antenna Control Interface*

ANTCTL[0:3] signals are used for tunable antenna control and should be routed to an appropriate antenna control circuitry.

More details about the interface will be added in the future version of the document.

Table 16: Pin Definition of Tunable Antenna Control Interface*

Pin Name	Pin No.	I/O	Description	Comment
ANTCTL0*	59	DO	Tunable antenna control	1.8V power domain
ANTCTL1*	61	DO	Tunable antenna control	1.8V power domain
ANTCTL2*	63	DO	Tunable antenna control	1.8V power domain
ANTCTL3*	65	DO	Tunable antenna control	1.8V power domain

NOTE

"*" means under development.

3.12. Configuration Pins

EM12-G provides 4 configuration pins, and it is configured as WWAN-USB 3.0 2.

Table 17: Pin Definition of Configuration Pins

Pin No.	Pin Name	I/O	Power Domain	Description
21	CONFIG_0		0	Connected to GND internally.
69	CONFIG_1		0	Connected to GND internally.
75	CONFIG_2		0	NC
1	CONFIG_3		0	NC

The 4 pins on EM12-G module are defined as below:

Table 18: List of Configuration Pins

Config_0 (Pin 21)	Config_1 (Pin 69)	Config_2 (Pin 75)	Config_3 (Pin 1)	Module Type and Main Host Interface	Port Configuration
GND	GND	NC	NC	WWAN-USB 3.0	2

4 GNSS Receiver

4.1. General Description

EM12-G includes a fully integrated global navigation satellite system solution that supports Gen9C-Lite of Qualcomm (GPS, GLONASS, BeiDou Galileo and QZSS).

EM12-G supports standard NMEA-0183 protocol, and outputs NMEA sentences at 1Hz data update rate via USB interface by default.

By default, EM12-G GNSS engine is switched off. It has to be switched on via AT command. For more details about GNSS engine technology and configurations, please refer to ***document [3]***.

5 Antenna Interfaces

EM12-G provides a main antenna interface, an Rx-diversity antenna interface which is used to resist the fall of signals caused by high speed movement and multipath effect, and a GNSS antenna interface. The antenna ports have an impedance of 50Ω.

5.1. Main/Rx-diversity Antenna Interfaces

The main/Rx-diversity/GNSS antenna interfaces are shown as below.

Figure 23: Antenna Interfaces on the Module

5.1.1. Operating Frequency

Table 19: EM12-G Operating Frequencies

3GPP Band	Transmit	Receive	Unit
WCDMA B1	1920~1980	2110~2170	MHz
WCDMA B2	1850~1910	1930~1990	MHz
WCDMA B3	1710~1785	1805~1880	MHz
WCDMA B4	1710~1755	2110~2155	MHz
WCDMA B5	824~849	869~894	MHz
WCDMA B8	880~915	925~960	MHz
WCDMA B9	1750~1785	1845~1880	MHz
WCDMA B19	830~845	875~890	MHz
LTE B1	1920~1980	2110~2170	MHz
LTE B2	1850~1910	1930~1990	MHz
LTE B3	1710~1785	1805~1880	MHz
LTE B4	1710~1755	2110~2155	MHz
LTE B5	824~849	869~894	MHz
LTE B7	2500~2570	2620~2690	MHz
LTE B8	880~915	925~960	MHz
LTE B9	1749.9~1784.9	1844.9~1879.9	MHz
LTE B12	699~716	729~746	MHz
LTE B13	777~787	746~756	MHz
LTE B14	788~798	758~768	MHz
LTE B17	704~716	734~746	MHz
LTE B18	815~830	860~875	MHz
LTE B19	830~845	875~890	MHz

LTE B20	832~862	791~821	MHz
LTE B21	1447.9~1462.9	1495.9~1510.9	MHz
LTE B25	1850~1915	1930~1995	MHz
LTE B26	814~849	859~894	MHz
LTE B28	703~748	758~803	MHz
LTE B29	/	717~728	MHz
LTE B30	2305~2315	2350~2360	MHz
LTE B32	/	1452~1496	MHz
LTE B38	2570~2620	2570~2620	MHz
LTE B39	1880~1920	1880~1920	MHz
LTE B40	2300~2400	2300~2400	MHz
LTE B41	2496~2690	2496~2690	MHz
LTE B66	1710~1780	2110~2200	MHz

5.2. GNSS Antenna Interface

The following table shows frequency specification of GNSS antenna interface.

Table 20: GNSS Frequency

Type	Frequency	Unit
GPS/Galileo	1575.42±1.023	MHz
GLONASS	1597.5~1605.8	MHz
BeiDou	1561.098±2.046	MHz

5.3. Antenna Installation

5.3.1. Antenna Requirements

The following table shows the requirements on main antenna, Rx-diversity antenna and GNSS antenna.

Table 21: Antenna Requirements

Type	Requirements
GNSS [1)]	Frequency range: 1559MHz ~ 1609MHz Polarization: RHCP or linear VSWR: < 2 (Typ.) Passive antenna gain: > 0dBi
WCDMA/LTE	VSWR: ≤ 2 Efficiency: > 30% Max Input Power: 50W Input Impedance: 50Ω Cable insertion loss: <1dB (WCDMA B5/B8/B19, LTE B5/B8/B12/B13/B14/B17/B18/B19/B20/B26/B28/B29) Cable insertion loss: <1.5dB (WCDMA B1/B2/B3/B4/B9, LTE B1/B2/B3/B4/B9/B21/B25/B32/B39/B66) Cable insertion loss <2dB (LTE B7/B30/B38/B40/B41)

NOTE

[1)] It is recommended to use a passive GNSS antenna when LTE B13 or B14 is supported, as the use of active antenna may generate harmonics which will affect the GNSS performance.

5.3.2. Recommended RF Connector for Antenna Installation

EM12-G is mounted with standard 2mm × 2mm receptacle RF connectors for convenient antenna connection. The connector dimensions are illustrated below:

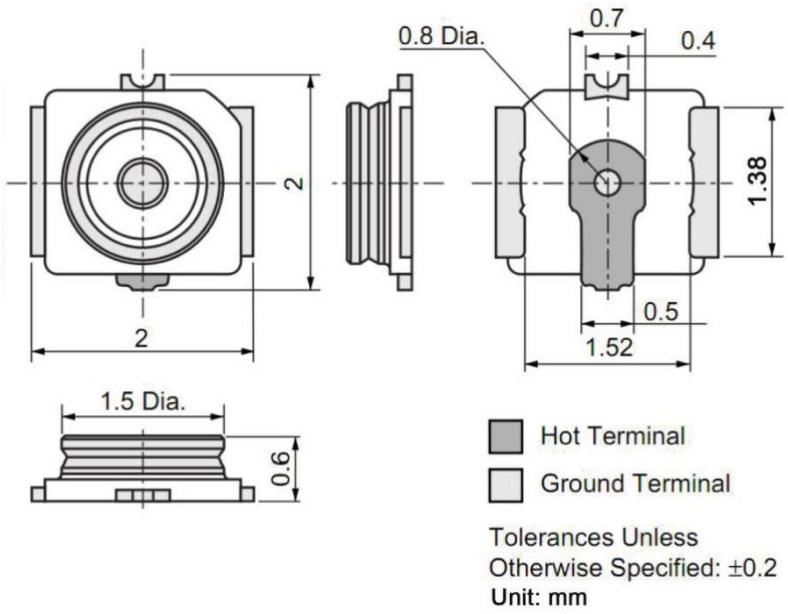


Figure 24: EM12-G RF Connector Dimensions (Unit: mm)

Table 22: Major Specifications of the RF Connector

Item	Specification
Nominal Frequency Range	DC to 6GHz
Nominal Impedance	50Ω
Temperature Rating	-40°C to +85°C
Voltage Standing Wave Ratio (VSWR)	Meet the requirements of: Max 1.3 (DC~3GHz) Max 1.45 (3GHz~6GHz)

The receptacle RF connector used in conjunction with EM12-G will accept two types of mating plugs that will meet a maximum height of 1.2mm using a Ø0.81mm coaxial cable or a maximum height of 1.45mm utilizing a Ø1.13mm coaxial cable.

The following figure shows the specifications of mating plugs using Ø0.81mm coaxial cables.

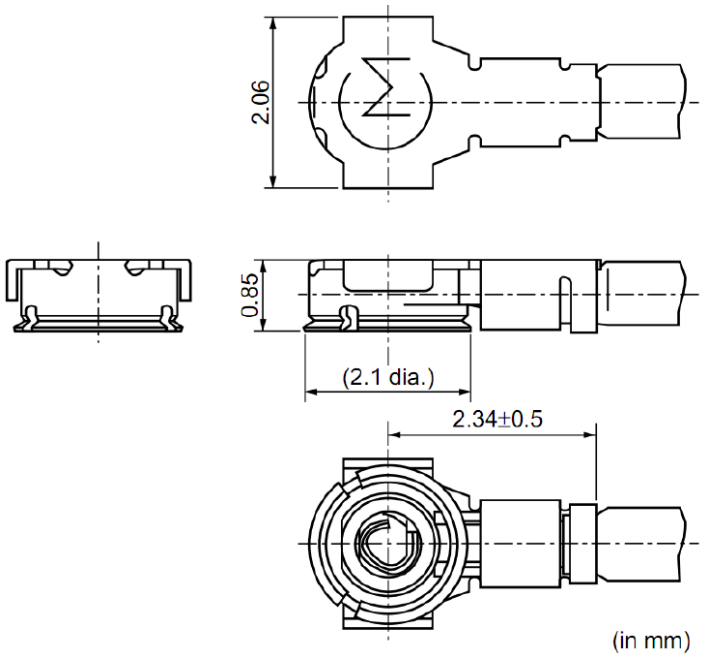


Figure 25: Specifications of Mating Plugs Using Ø0.81mm Coaxial Cables

The following figure illustrates the connection between the receptacle RF connector on EM12-G and the mating plug using a Ø0.81mm coaxial cable.

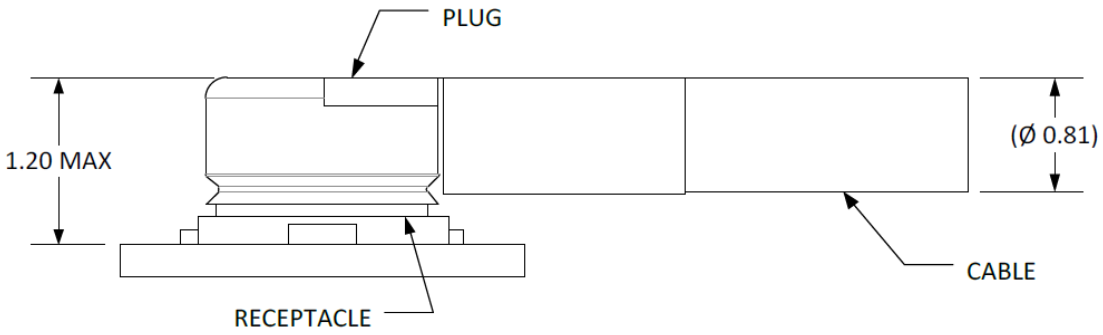


Figure 26: Connection between RF Connector and Mating Plug Using Ø0.81mm Coaxial Cable

The following figure illustrates the connection between the receptacle RF connector on EM12-G and the mating plug using a Ø1.13mm coaxial cable.

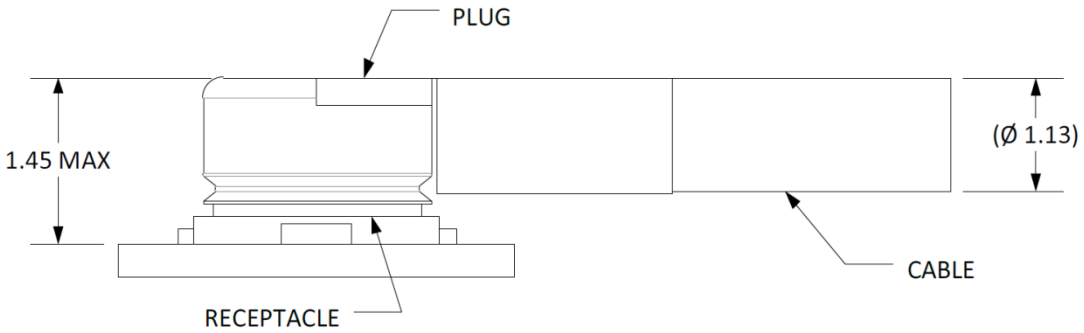


Figure 27: Connection between RF Connector and Mating Plug Using Ø1.13mm Coaxial Cable

6 Electrical, Reliability and Radio Characteristics

6.1. Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital and analog pins of the module are listed in the following table.

Table 23: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VCC	-0.3	4.7	V
Voltage at Digital Pins	-0.3	2.3	V

6.2. Power Supply Requirements

The typical input voltage of EM12-G is 3.7V, as specified by *PCIe M.2 Electromechanical Spec Rev1.0*. The following table shows the power supply requirements of EM12-G.

Table 24: Power Supply Requirements

Parameter	Description	Min.	Typ.	Max.	Unit
VCC	Power Supply	3.135	3.7	4.4	V

6.3. I/O Requirements

Table 25: I/O Requirements

Parameter	Description	Min.	Max.	Unit
V_{IH}	Input high voltage	0.7 × V_{DD18} 1)	V_{DD18}+0.3	V
V_{IL}	Input low voltage	-0.3	0.3 × V_{DD18}	V
V_{OH}	Output high voltage	V_{DD18}-0.5	V_{DD18}	V
V_{OL}	Output low voltage	0	0.4	V

NOTE

1) V_{DD18} refers to I/O power domain.

6.4. Operation and Storage Temperatures

Table 26: Operation and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operation Temperature Range 1)	-30	+25	+70	ºC
Extended Temperature Range 2)	-40		+85	ºC
Storage temperature Range	-40		+90	ºC

NOTES

1. 1) Within operation temperature range, the module is 3GPP compliant.
2. 2) Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to the normal operating temperature levels, the module will meet 3GPP specifications again.

6.5. Current Consumption(TBD)

6.6. RF Output Power

The following table shows the RF output power of EM12-G module.

Table 27: RF Output Power

Frequency	Max.	Min.
WCDMA bands	24dBm+1/-3dB	<-50dBm
LTE- FDD bands	23dBm±2dB	<-40dBm
LTE-TDD bands	23dBm±2dB	<-40dBm

6.7. RF Receiving Sensitivity

The following tables show conducted RF receiving sensitivity of EM12-G module.

Table 28: EM12-G Conducted RF Receiving Sensitivity(PRX、DRX TBD)

Frequency	Primary (Typ.)	Diversity (Typ.)	SIMO[1] (Typ.)	3GPP (SIMO)
WCDMA B1	-109.5	/	/	-106.7dBm
WCDMA B2	-109.5	/	/	-104.7dbm
WCDMA B3	-109.5	/	/	-103.7dbm
WCDMA B4	-109.0	/	/	-106.7dBm
WCDMA B5	-110.5	/	/	-104.7dbm
WCDMA B8	-110.5	/	/	-103.7dBm
WCDMA B9	-109.5	/	/	-105.7dBm
WCDMA B19	-110.5	/	/	-106.7dBm
LTE-FDD B1 (10M)	-96.5	-96.0	-98.5dbm	-96.3dBm

LTE-FDD B2 (10M)	-97.5	-97.0	-99.5dbm	-94.3dBm
LTE-FDD B3 (10M)	-97.0	-96.5	-99.0dbm	-93.3dBm
LTE-FDD B4 (10M)	-97.0	-96.0	-99.0dBm	-96.3dBm
LTE-FDD B5 (10M)	-98.5	-98.5	-100.5dBm	-94.3dBm
LTE-FDD B7 (10M)	-96.5	-96.0	-98.5dBm	-94.3dBm
LTE-FDD B8 (10M)	-98.0	-98.0	-101.5dBm	-93.3dBm
LTE-FDD B9(10M)	-97.5	-97.5	-100.0dBm	-95.3dBm
LTE-FDD B12 (10M)	-98.5	-99.0	-101.5dBm	-93.3dBm
LTE-FDD B13 (10M)	-99.0	-99.0	-101.0dBm	-93.3dBm
LTE-FDD B14 (10M)	-97.0	-97.5	-100.0dBm	-93.3dBm
LTE-FDD B17 (10M)	-99.0	-99.0	-101.0dBm	-93.3dBm
LTE-FDD B18 (10M)	-99.0	-99.0	-101.0dBm	-96.3dBm
LTE-FDD B19 (10M)	-98.5	-98.5	-100.5dBm	-96.3dBm
LTE-FDD B20 (10M)	-98.5	-98.5	-100.5dBm	-93.3dBm
LTE-FDD B21 (10M)	-96.0	-96.0	-98.0dBm	-96.3dBm
LTE-TDD B25 (10M)	-96.5	-97.0	-99.0dBm	-92.8dBm
LTE-TDD B26 (10M)	-99.0	-98.5	-100.5dBm	-93.8dBm
LTE-TDD B28 (10M)	-98.0	-99.0	-100.5dBm	-94.8dBm
LTE-TDD B29 (10M)	/	/	/	/
LTE-TDD B30 (10M)	-97.0	-95.0	-98.0dBm	-95.3dBm
LTE-TDD B32 (10M)	/	/	/	/
LTE-TDD B38 (10M)	-96.5	-96.0	-98.0dBm	-96.3dBm
LTE-TDD B39 (10M)	-97.0	-97.5	-99.5dBm	-96.3dBm
LTE-TDD B40 (10M)	-96.5	-96	-98.0dBm	-96.3dBm
LTE-TDD B41 (10M)	-96.0	-95.5	-97.5dBm	-94.3dBm

LTE-TDD B66 (10M)	-97.0	-96.0	-99.0dBm	-95.8dBm

NOTES

1. [1)] SIMO is a smart antenna technology that uses a single antenna at the transmitter side and multiple (two for EM12-G) antennas at the receiver side, which can improve Rx performance.
2. [2)] Per 3GPP specification.

6.8. ESD Characteristics

The module is not protected against electrostatic discharge (ESD) in general. Consequently, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates the module.

The following table shows the module electrostatic discharge characteristics.

Table 29: Electrostatic Discharge Characteristics (Temperature: 25ºC, Humidity: 40%)

Tested Points	Contact Discharge	Air Discharge	Unit
VBAT, GND	±5	±10	kV
Antenna Interfaces	±4	±8	kV
Other Interfaces	±0.5	±1	kV

6.9. Thermal Dissipation

EM12-G is designed to work over an extended temperature range. In order to achieve a maximum performance while working under extended temperatures or extreme conditions (such as with maximum power or data rate, etc.) for a long time, it is strongly recommended to add a thermal pad or other thermally conductive compounds between the module and the main PCB for thermal dissipation.

The thermal dissipation area (i.e. the area for adding thermal pad) is show as below. The dimensions are measured in mm.

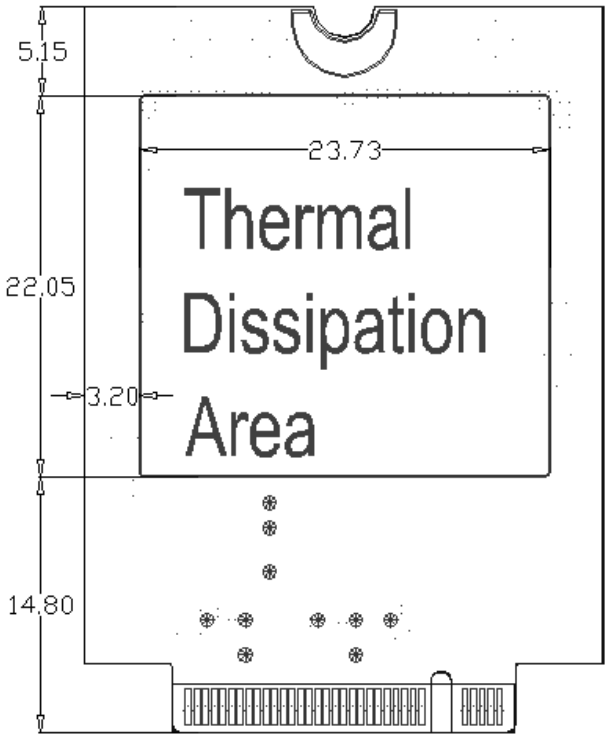


Figure 28: Thermal Dissipation Area on Bottom Side of Module (Top View)

There are some other measures to enhance heat dissipation performance:

- Add ground vias as many as possible on PCB.
- Maximize airflow over/around the module.
- Place the module away from other heating sources.
- Module mounting holes must be used to attach (ground) the device to the main PCB ground.
- It is NOT recommended to apply solder mask on the main PCB where the module's thermal dissipation area is located.
- Select an appropriate material, thickness and surface for the outer housing (i.e. the mechanical enclosure) of the application device that integrates the module so that it provides good thermal dissipation.
- Customers may also need active cooling to pull heat away from the module.
- If possible, add a heatsink on the top of the module. A thermal pad should be used between the heatsink and the module, and the heatsink should be designed with as many fins as possible to increase heat dissipation area.

7 Mechanical Dimensions and Packaging

This chapter mainly describes mechanical dimensions and packaging specifications of EM12-G module. All dimensions are measured in mm, and the tolerances for dimensions without tolerance values are ±0.05mm.

7.1. Mechanical Dimensions of the Module

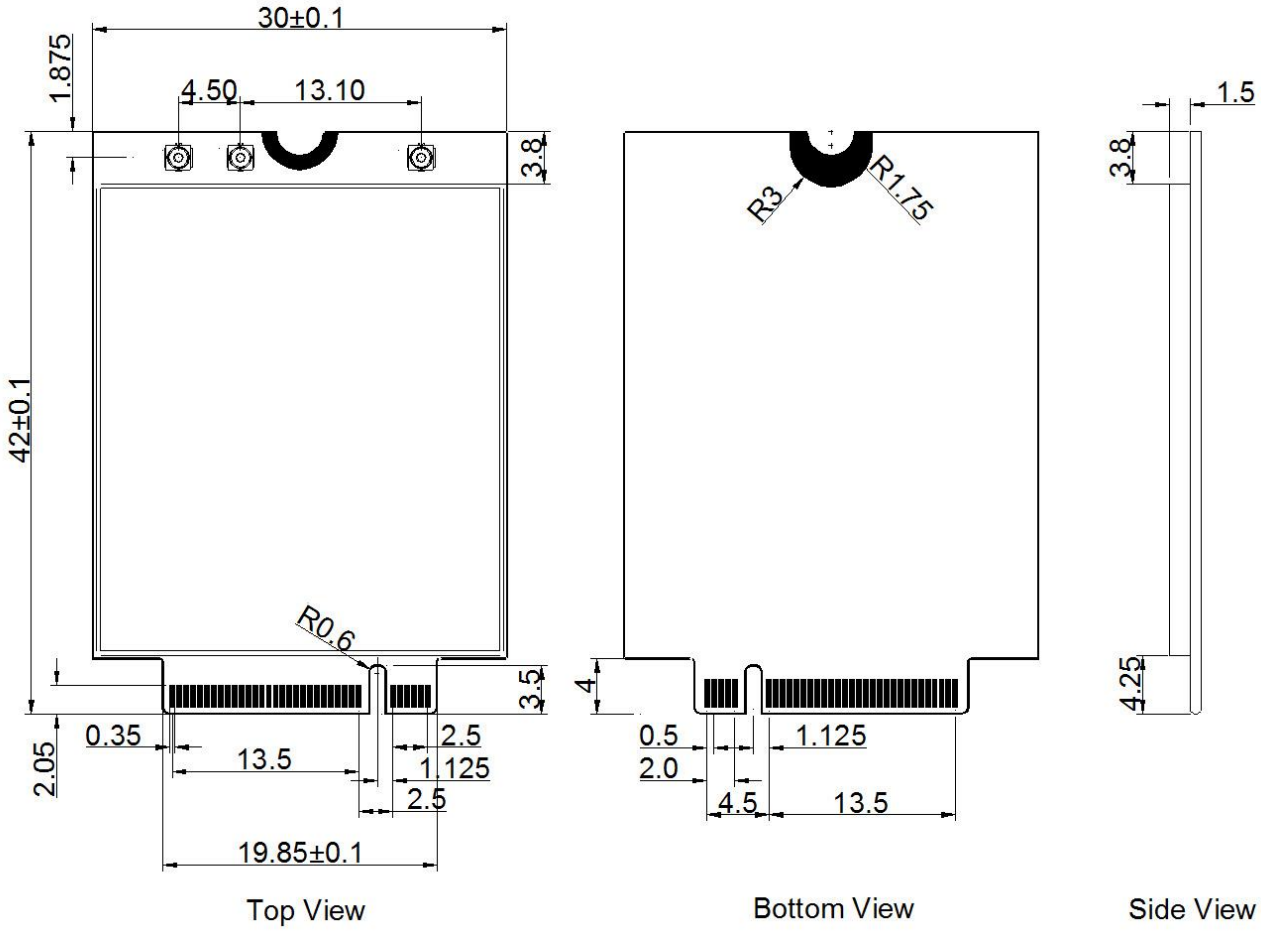


Figure 29: Mechanical Dimensions of EM12-G (Unit: mm)

7.2. Standard Dimensions of M.2 PCI Express

The following figure shows the standard dimensions of M.2 PCI Express. Please refer to ***document [4]*** for detailed A and B.

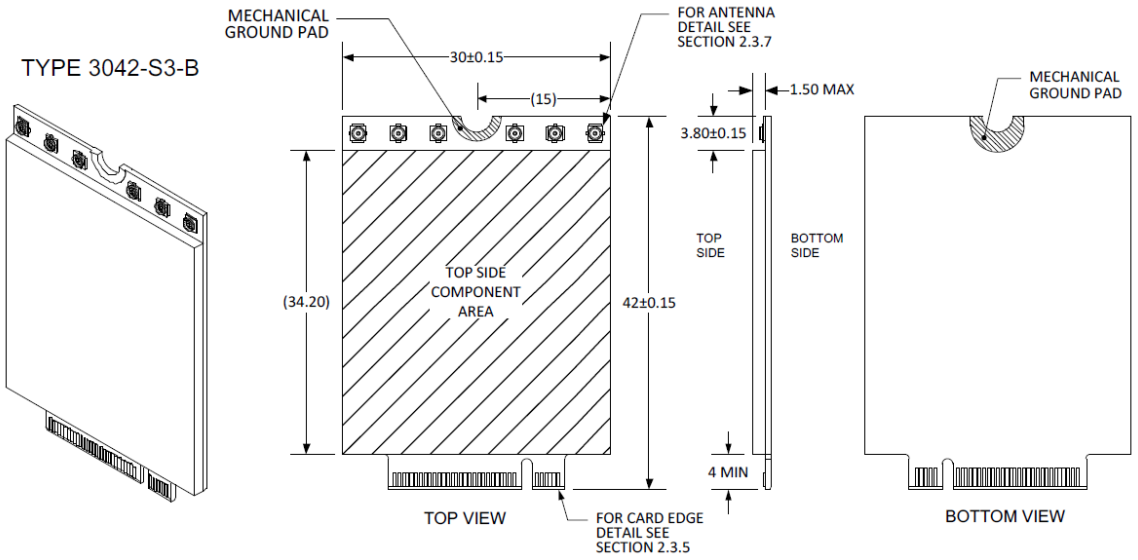
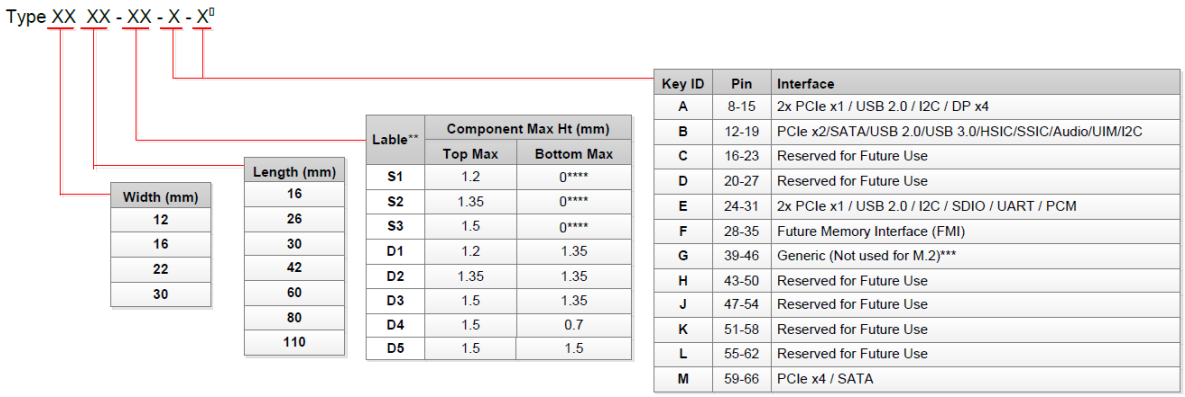


Figure 30: Standard Dimensions of M.2 Type 3042-S3 (Unit: mm)

According to M.2 nomenclature, EM12-G is Type 3042-S3-B (30.0mm × 42.0mm, max component height on the top is 1.5mm and single-sided, key ID is B).



Width (mm)
12
16
22
30

Length (mm)
16
26
30
42
60
80
110

Lable**	Component Max Ht (mm)	
	Top Max	Bottom Max
S1	1.2	0****
S2	1.35	0****
S3	1.5	0****
D1	1.2	1.35
D2	1.35	1.35
D3	1.5	1.35
D4	1.5	0.7
D5	1.5	1.5

Key ID	Pin	Interface
A	8-15	2x PCIe x1 / USB 2.0 / I2C / DP x4
B	12-19	PCIe x2/SATA/USB 2.0/USB 3.0/HSIC/SSIC/Audio/UIM/I2C
C	16-23	Reserved for Future Use
D	20-27	Reserved for Future Use
E	24-31	2x PCIe x1 / USB 2.0 / I2C / SDIO / UART / PCM
F	28-35	Future Memory Interface (FMI)
G	39-46	Generic (Not used for M.2)***
H	43-50	Reserved for Future Use
J	47-54	Reserved for Future Use
K	51-58	Reserved for Future Use
L	55-62	Reserved for Future Use
M	59-66	PCIe x4 / SATA

* Use ONLY when a double slot is being specified
** Label included in height dimension
*** Key G is intended for custom use. Devices with this key will not be M.2-compliant. Use at your own risk!
**** Insulating label allowed on connector-based designs

Figure 31: M.2 Nomenclature

7.3. Design Effect Drawings of the Module

Figure 32: Top View of the Module

NOTE

These are design effect drawings of EM12-G module. For more accurate pictures, please refer to the module that you get from Quectel.

7.4. M.2 Connector

EM12-G adopts a standard PCI Express M.2 connector which compiles with the directives and standards listed in the ***document [4]***.

7.5. Barcode Rule

The **PN (Q1-A2449)** printed on the label is fixed for Quectel.

For the **SN** shown in the top view, the first two digits indicate project stage. For example, “D1” means DVT1. The next one digit indicates the code of the factory where the module is manufactured. The next

four digits indicate the day, month and year when the module is manufactured. For instance, “18FD” means 13th June, 2018. The next two digits indicate serial number of the manufacturing order. The last six digits vary by module which could not be the same in certain time. Meanwhile, the **SN** and **IMEI** can be checked by scanning the QR code.

7.6. Packaging

EM12-G modules are packaged in trays. The following figure shows the tray size.

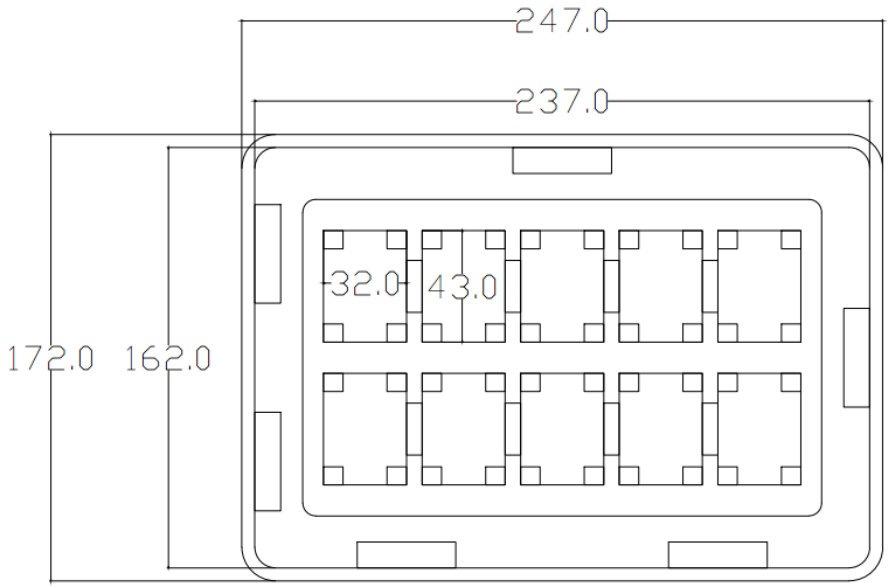


Figure 33: Tray Size

Each tray contains 10 modules. The smallest package contains 100 modules. Tray packaging procedure as below.

1. Use 10 trays to package 100 modules at a time (tray size: 247mm × 172mm).
2. Place an empty tray on the top of the 10-tray stack.
3. Fix the stack with masking tape in “#” shape as shown in the figure.
4. Pack the stack with conductive bag, and then fix the bag with masking tape.
5. Place the IMEI No. list into the small carton.
6. Seal the carton and then label the seal with sealing sticker (small carton size: 250mm × 175mm × 128mm).

Figure 34: Tray Packaging Procedure

8 Appendix References

Table 30: Related Documents

SN	Document Name	Remark
[1]	Quectel_M.2_EVB_User_Guide	M.2 EVB User Guide
[2]	Quectel_EP06&EG06&EM06_AT_Commands_Manual	EP06, EG06 and EM06 AT Commands Manual
[3]	Quectel_EP06&EG06&EM06_GNSS_AT_Commands_Manual	EP06, EG06 and EM06 GNSS AT Commands Manual
[4]	PCI Express M.2 Specification	PCI Express Specification

Table 31: Terms and Abbreviations

Abbreviation	Description
bps	Bits Per Second
DC-HSPA+	Dual-carrier High Speed Packet Access
DFOTA	Delta Firmware Upgrade Over The Air
DL	Down Link
ESD	Electrostatic Discharge
FDD	Frequency Division Duplexing
GLONASS	GLObalnaya Navigatsionnaya Sputnikovaya Sistema, the Russian Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HR	Half Rate
HSPA	High Speed Packet Access

HSUPA	High Speed Uplink Packet Access
kbps	Kilo Bits Per Second
LED	Light Emitting Diode
LTE	Long Term Evolution
Mbps	Million Bits Per Second
ME	Mobile Equipment (Module)
MIMO	Multiple-Input Multiple-Output
MLCC	Multiplayer Ceramic Chip Capacitor
MMS	Multimedia Messaging Service
MO	Mobile Originated
MT	Mobile Terminated
PDU	Protocol Data Unit
PPP	Point-to-Point Protocol
RF	Radio Frequency
Rx	Receive
SAR	Specific Absorption Rate
SMS	Short Message Service
Tx	Transmit
UART	Universal Asynchronous Receiver & Transmitter
UL	Up Link
URC	Unsolicited Result Code
(U)SIM	(Universal) Subscriber Identification Module
WCDMA	Wideband Code Division Multiple Access